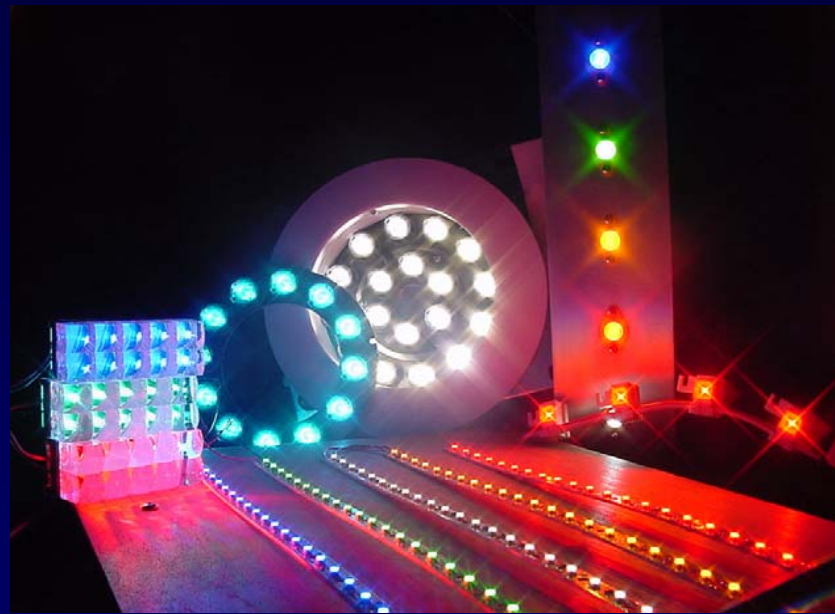


LRC Partner Visit to
California Energy Commission
April 8, 2003



LED Research Update

LED Performance

Goal:

To benchmark LED performance

High-Flux LEDs – Parameters considered

Light Output

- Total flux per package

- Efficacy

- Dimming effects

- Lumen maintenance and life

Color

- CRI , SPD

- CCT

- CIE x,y

 - Between devices

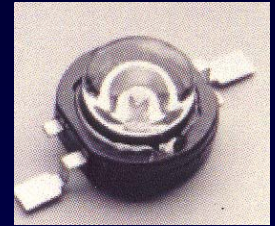
 - With temperature

 - Over time

High-Flux LEDs – Commercial Products

LumiLeds

Red, Green, Blue, and White
Luxeon LEDs



OSRAM OPTO

White (available: Late 2003)



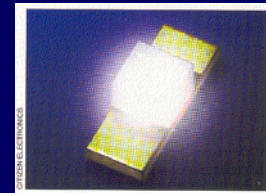
Optotechnologies

White

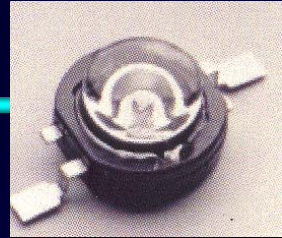


Nichia

White (available: Mid 2003)



Light Output and Efficacy



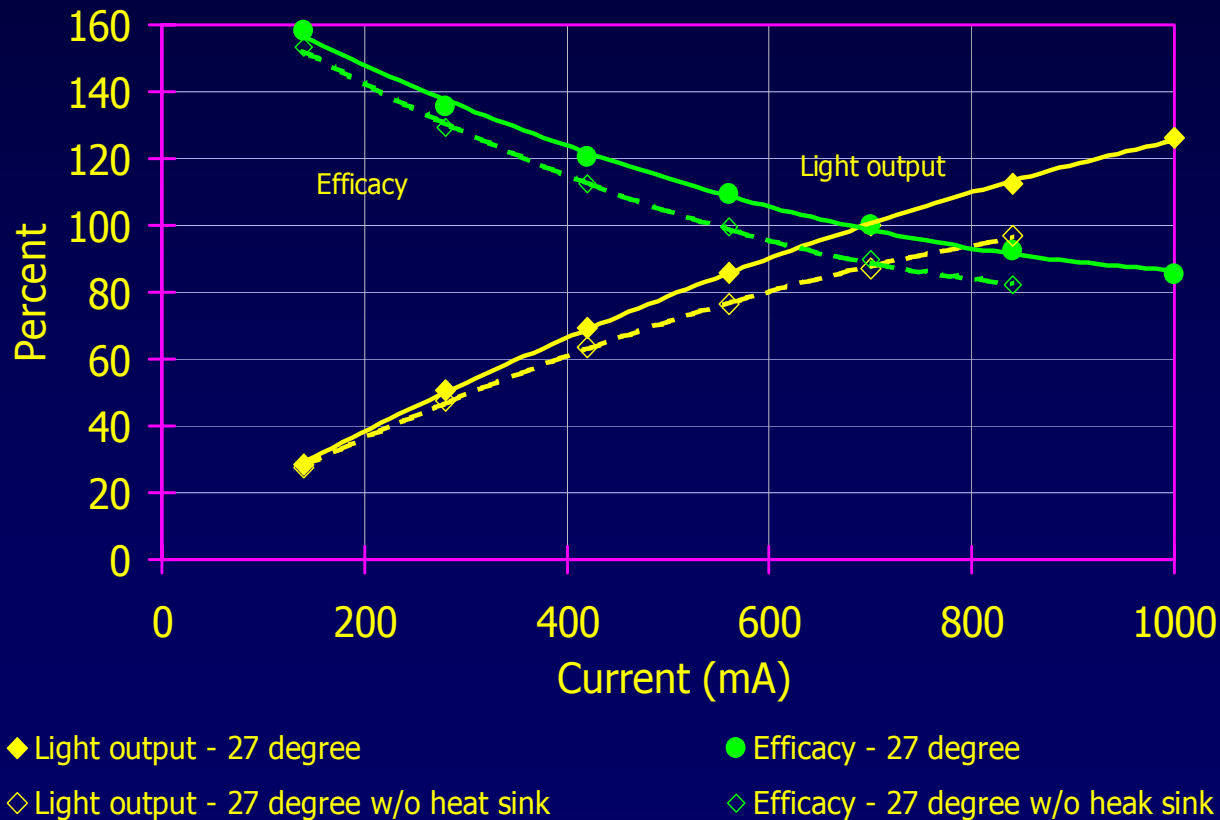
Flux per package

18 lm

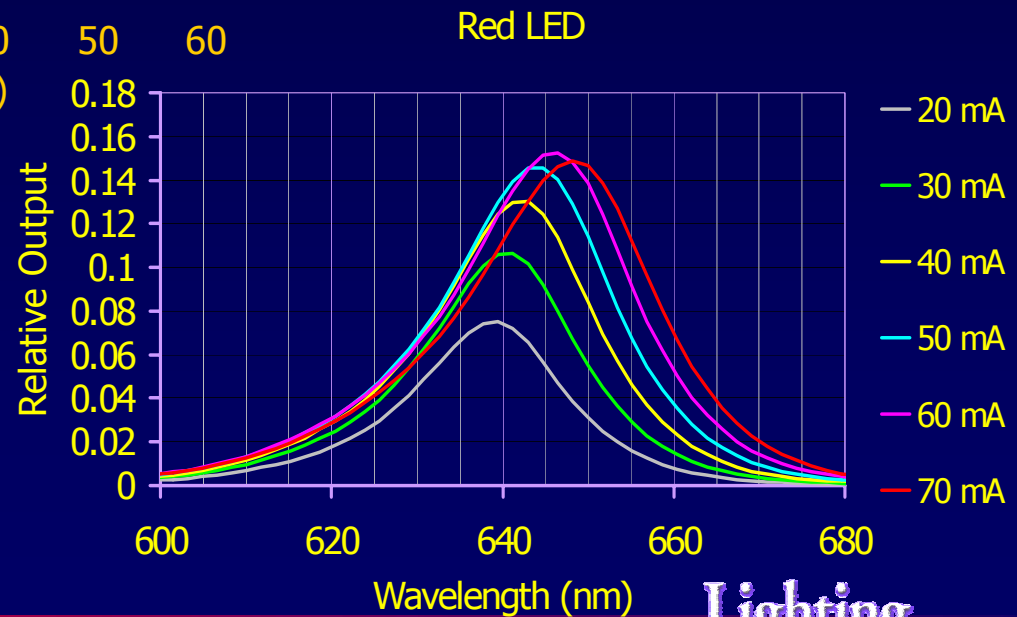
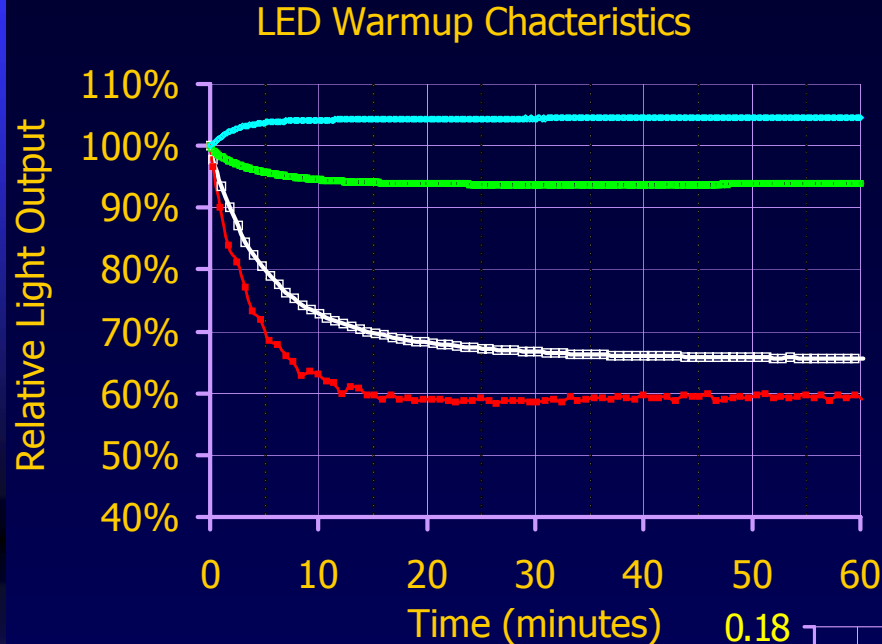
Efficacy

16 lm/W

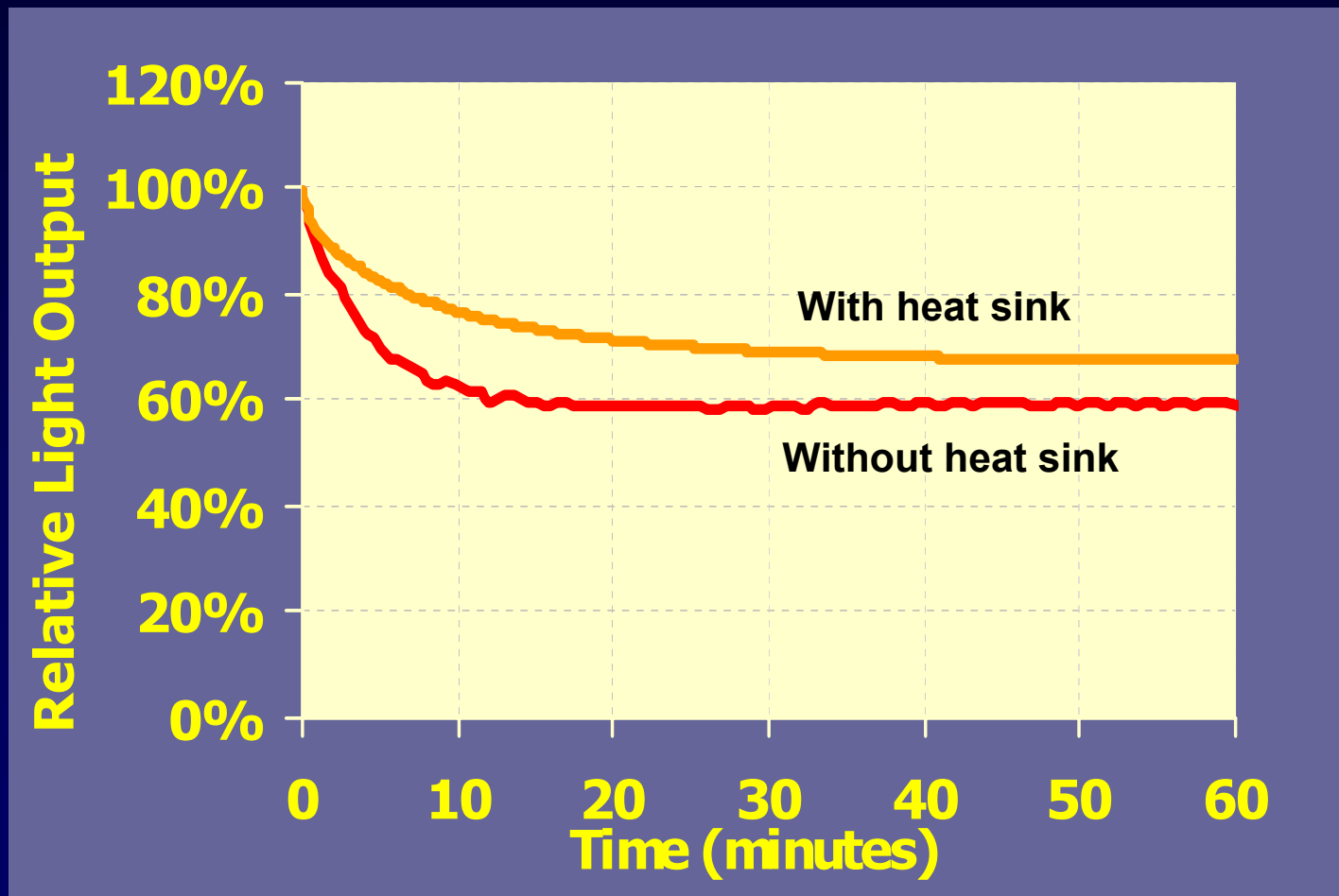
Light Output & Efficacy vs. Current



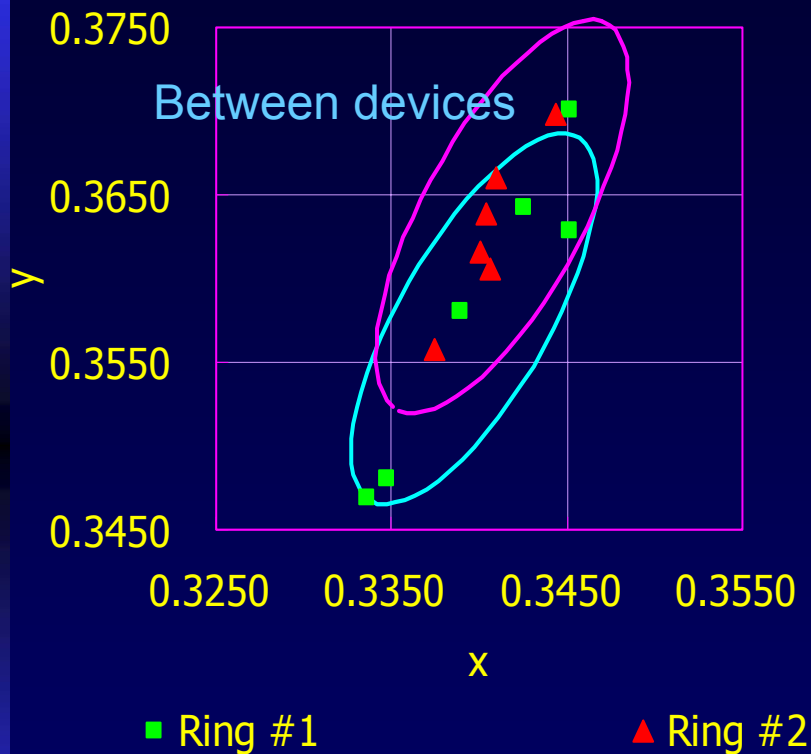
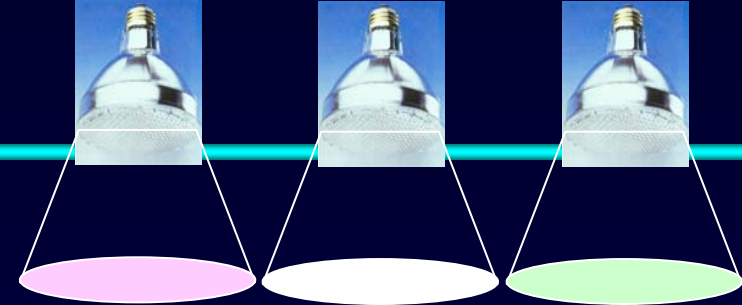
Warm-up Characteristics



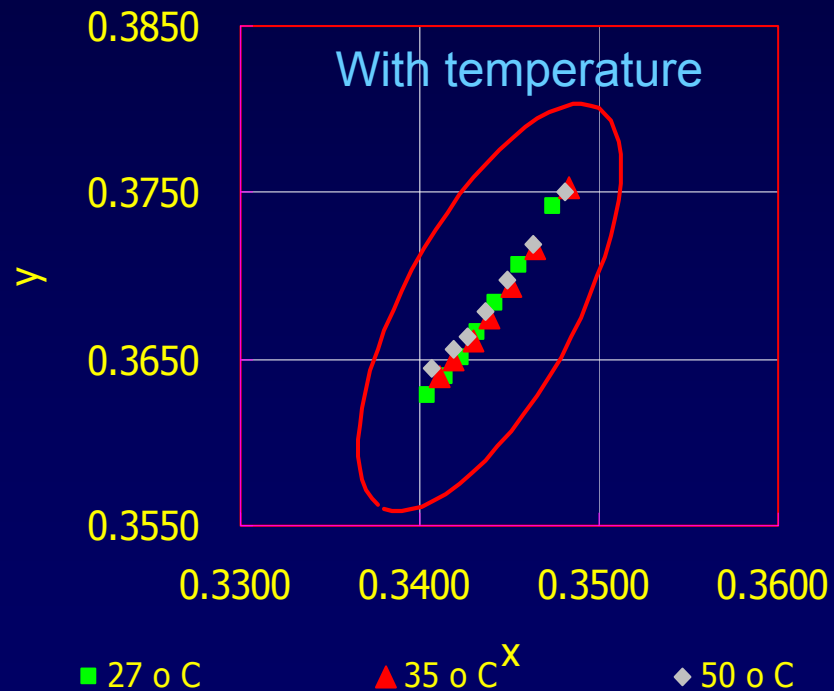
Impact of Using Heat Sink



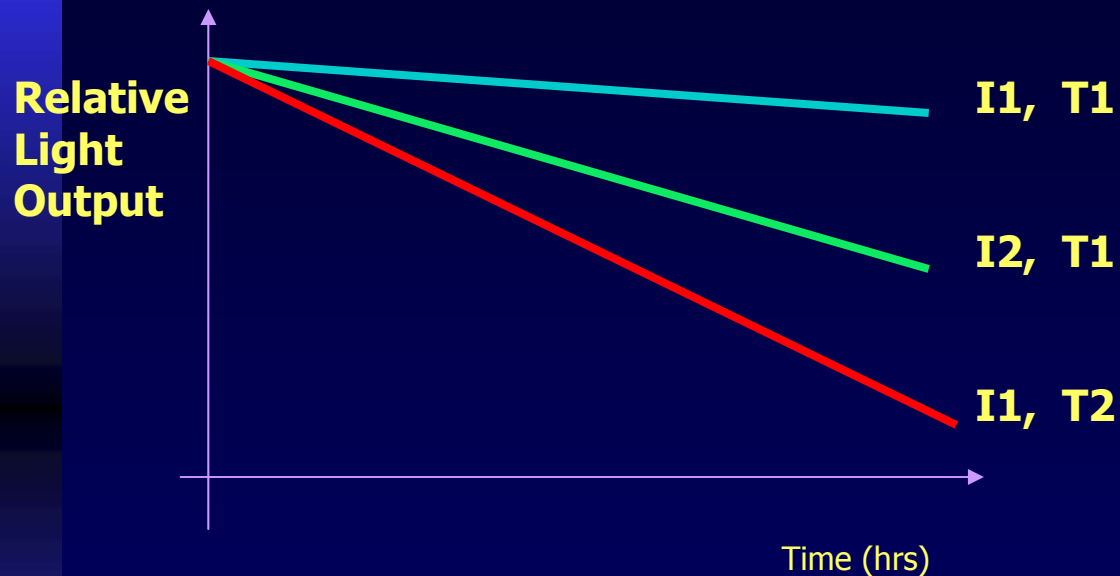
Color Variations



Within 4-step Mac Adam Ellipse



LED Life Test Variables

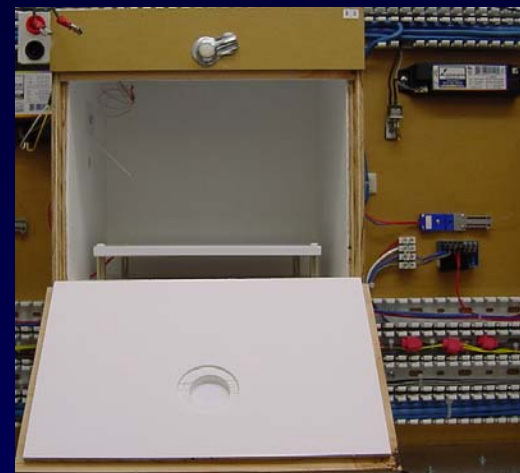
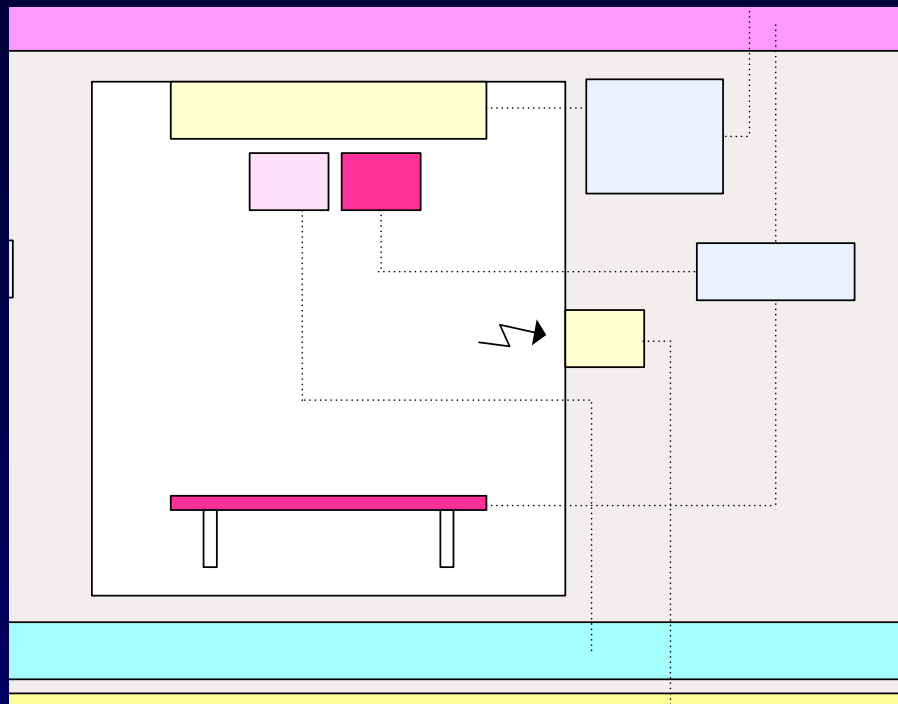


- Two Temperature
- Two Drive Current

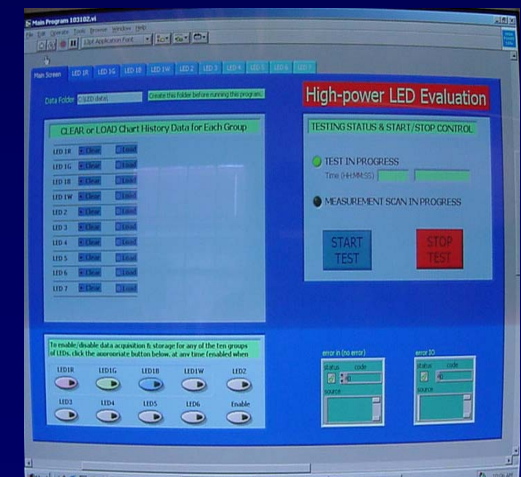
- Light Degradation
- Color Shift
- Power Consumption

Relative light output as a function of time

LED Life Test Setup



LED Life Test Setup

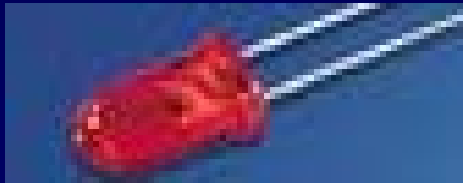


Estimating LED Life – Alternate method

Goal:

To identify a fast and easy way to estimate LED degradation rate.

Initial study with AlGaInP LEDs



Cause for LED Degradation

Heat at the junction is one of the primary causes of LED degradation.

$$T_j = f(P_j, T_a, \theta)$$

P_j = Power dissipated at the junction ($V \cdot I$)

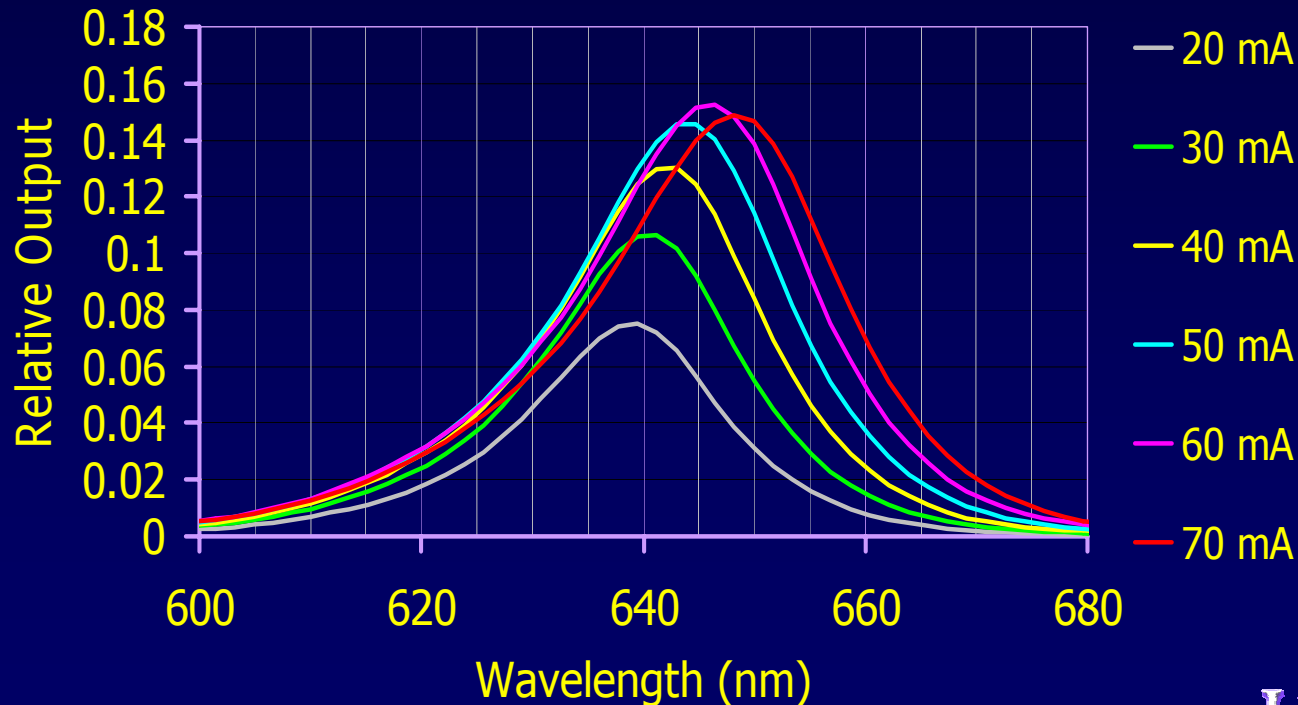
T_a = Ambient temperature

θ = Thermal resistance coefficient ($^{\circ}\text{C}/\text{W}$)

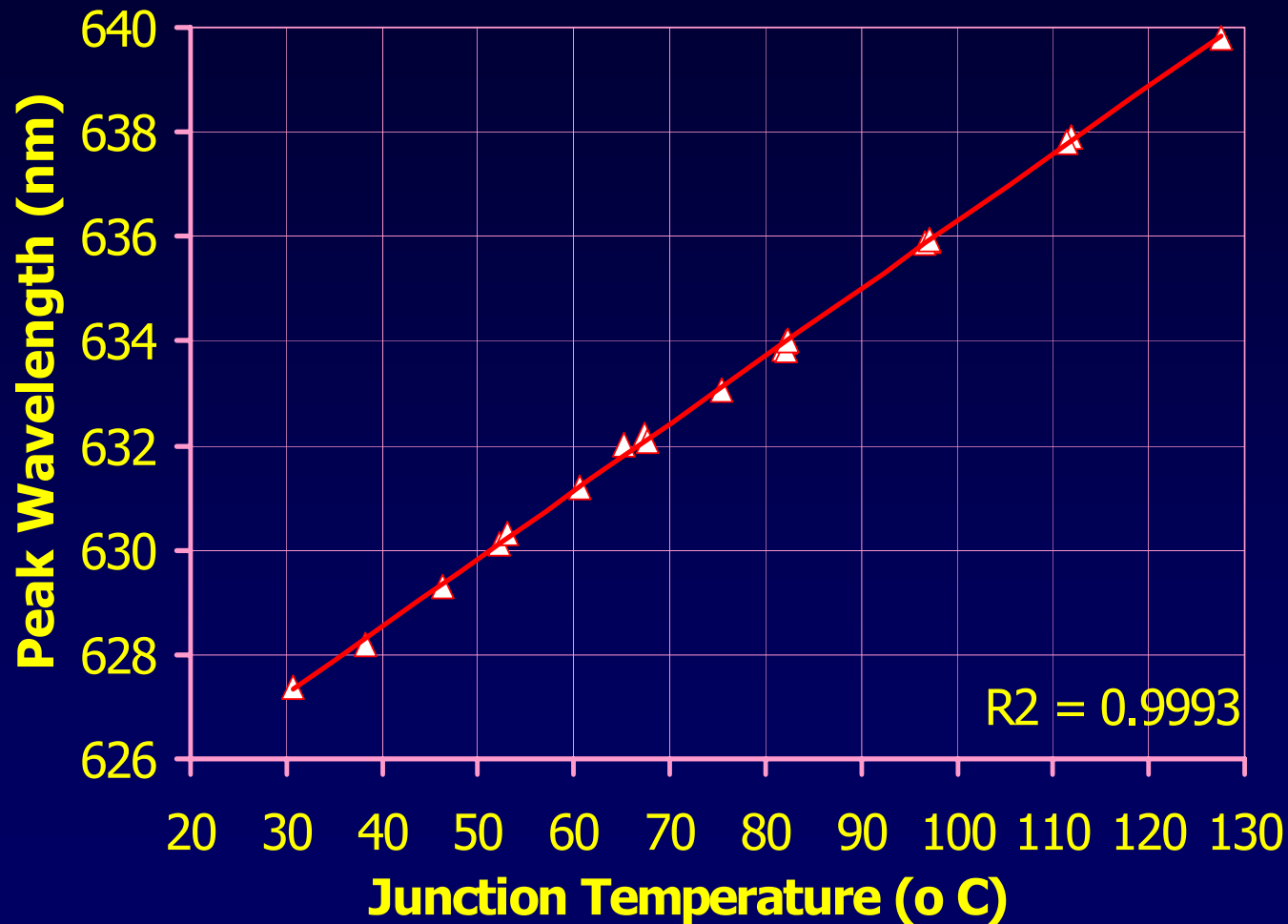
Estimating Junction Temperature

As junction temperature increases, the peak wavelength of AlGaInP LEDs shifts proportionally to the longer wavelengths.

Red LED



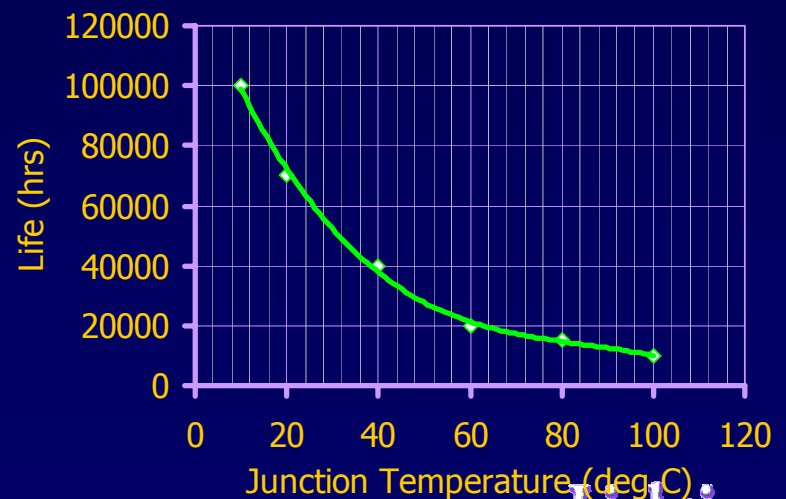
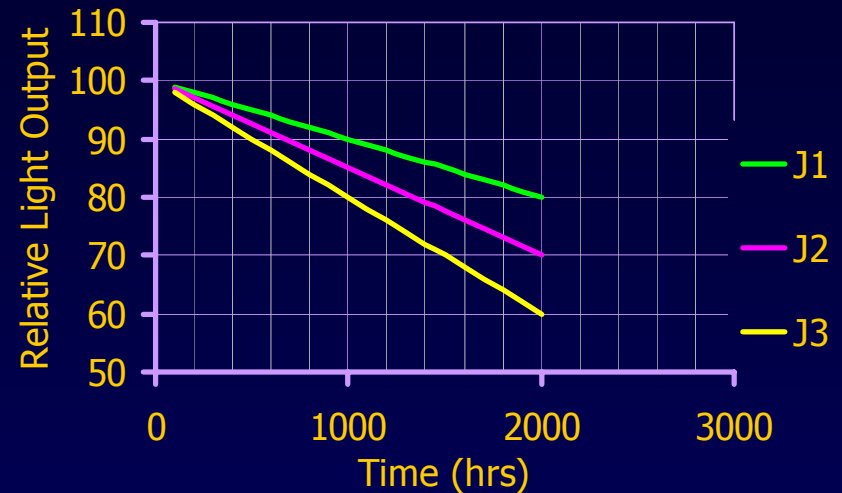
Peak λ vs Junction Temperature



Eugene Hong, LRC 2002
(5 mm Red LEDs)

Work in progress

- ❑ Link spectral shift to LED Life.
- ❑ Develop similar methods to estimate junction temperature of other LED materials (such as GaN).



LEDs for Back Lighted Signs

Back Lighted Signs



Current practice:

Neon

Cold-cathode fluorescent

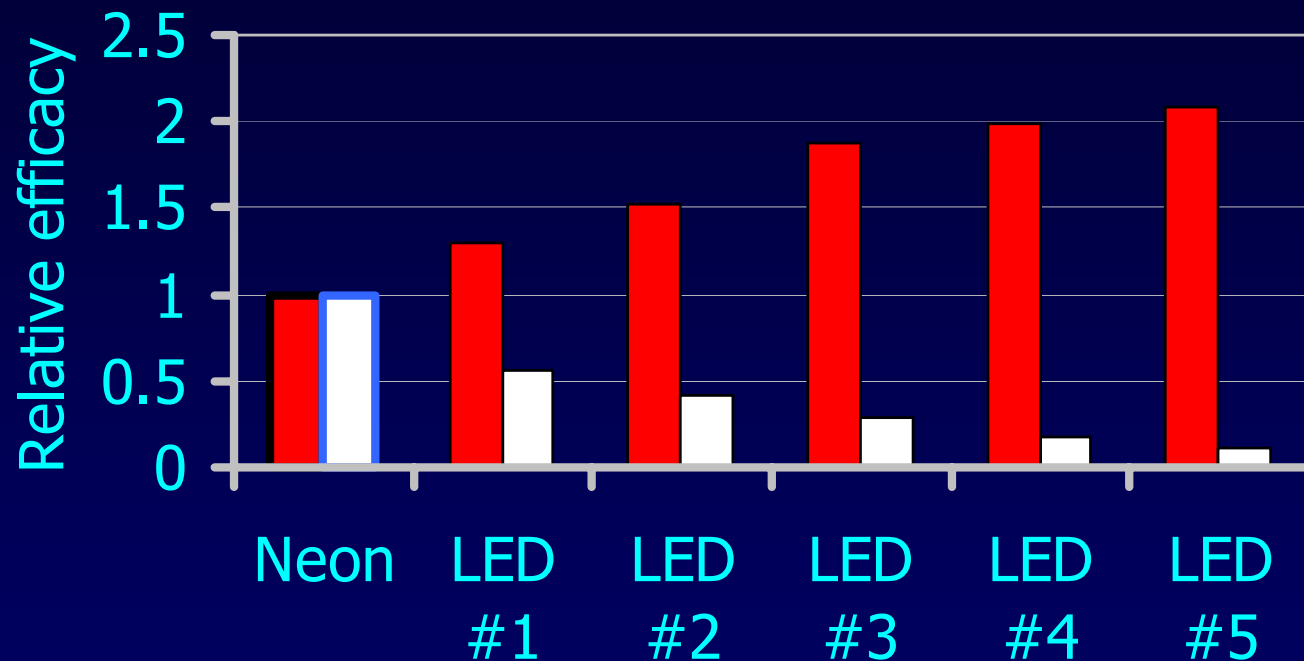
Potential new source

LED



Back Lighted Signs

Neon vs LED



Presently LEDs are more energy efficient than neon only in certain colors.

Other Activities

Low Profile Luminaires - CEC

Field Studies

Supermarket refrigerators – NYSERDA

Display window – LA Water and Power Dept.



CEC - Low Profile Luminaires

Objectives

- Develop two types of low profile prototype LED luminaires that
 - ◆ Shows promise of decreasing energy use for application by up to 20%
 - ◆ Takes advantage of full range dimming control of LEDs (manual dimming, load shed, daylighting)

Objectives

Typical Expected Applications

- ◆ Under cabinet lighting
- ◆ Retail display lighting
- ◆ Elevator lighting
- ◆ Task Lighting



Under-cabinet lighting



Elevator lighting

Tasks and deadlines

Tasks	Deadline
1. LED Evaluation and Light Source Specification Development	Feb/March 2003
2. Development of Ballast/Control System Specification	May 2003
3. Analysis of Application Design	June 2003
4. Optical Design and Modeling	Jan 2004
5. Gain Input from Luminaire Manufacturers & Lighting Designers	Feb 2004

Tasks and deadlines

Tasks	Deadline
6. Refine, Build and Test Prototypes	June 2004
7. Technology Transfer Activities	Aug 2004
8. Production Readiness Plan	Sep 2004
9. Monthly Progress Reports	Monthly
10. Annual Report	Annually
11. Final Report	Oct 2004

Task Progress

Task 1:

Evaluation and Light Source Specification Development

Evaluation of LEDs available in the market based on

- ◆ Available LED Packages
- ◆ Color Properties
- ◆ Lumen output and efficacy
- ◆ Thermal Management
- ◆ Light Distribution
- ◆ Controllability



5mm LEDs



Emitter (high flux LEDs)

LED packages

Task Progress

■ Conclusion

- ◆ High flux LEDs will be most appropriate for the low profile luminaire applications
- ◆ Type of LEDs (Phosphor or RGB based) yet to be decided

Based on the selection, detailed specification of the LEDs will be done.

Task Progress

Task 2:

Development of Ballast/Control System Specification

List of drivers (ballast/control system) available in the market

- Commercially available
- Custom drivers

Evaluation of drivers in progress



Commercially available driver



Customized driver

Task Progress

Task 3: Analysis of Application Design

List of Potential applications

- ◆ *Task lighting – Desktop luminaire application*
- ◆ *Under cabinet lighting – Kitchen application*
- ◆ *In-shelf lighting for shelves, cupboards and wardrobes*
- ◆ *Cove lighting*
- ◆ *Step lighting*
- ◆ *Refrigerated display case lighting*
- ◆ *Elevator down lighting*
- ◆ *Miniature track lighting - display applications*

Task Progress

Evaluation criteria for applications

Task	Horizontal Illuminance (lux)	Vertical Illuminance (lux)	CCT (K)	CRI	Typical source	Lumens/ fixture (lm)	Energy (W)
Under-cabinet	500	100	3000-6500	75	Fluorescents, halogens	800-2100	30-100
Elevator	50	30	2800-3500	80	PAR, MR halogens, Fluorescents	800-2100	30-60
Retail Display	1000	300	2800-3500	85	PAR, MR halogens	500-1000	30-75
Task lighting	300	30	2800-3500	80	Incandescent, fluorescent	800-1100	15-75

Low Profile Luminaire Experimental Prototype

